Section 1

Chapter 4 - Reviewing Solutions for Augmented and Virtual Reality

Theoretical Framework

4.1: What Do We Mean By Ar And Vr?

Conceptualizing the AR and VR. We can rely on the traditional proposal made by Milgram and Kishino with their reality-virtuality continuum (Figure 1).

MIXED REALITY			
-----------------→		←-------------------	
REAL CONTEXT	AUGMENTED REALITY	AUGMENTED VIRTUAL	VIRTUAL CONTEXT
		REALITY-VIRTUALITY CONTINUUM	

Figure No. 1. Reality-virtuality continuum of Milgram and Kishino.

As seen in this continuum, AR would be closer to the real context, while VR would be at one end, the "Augmented Virtual Reality" or "Mixed Reality" being in the center. Technology, the latter incorporates elements of AR and VR.

Another way to characterize it is to consider that the AR reality is combined with information elements available on the technological devices used to reach a new reality, while in VR, the person is in a technologically-immersive environment, created artificially, and thus not seeing a mixed reality (Johnson and Adams, 2016). The first mixes reality with the virtual, and in the second what is encouraged is the location of the subject in an alternate world artificially created through computers and where different types of sensory experiences occur. As Brigham (2017) points out, the fundamental difference is that in the AR subject stays in one place, while with VR, he or she moves to another place. In short, we could say that the first subject is located in his or her real context, while the second relocates away from it. Both provide completely different ways of interaction between the subject and the real world.

Cabero and Garcia (2016, 7) state that "this is a technology that allows the combination of digital information and physical information in real time through various technological supports such as tablets or smartphones, thereby creating a new enriched reality. " Meanwhile, for Canellas (2017), VR "is a technology that enables the user, using an VR viewer, to dive into virtual scenarios, in first person and 360º. This encourages the user to feel immersed in these scenarios, and even interact with the elements that compose them. The user stops seeing the place in which he or she is located, to move to visualize and interact with "another reality".

The separation between the two technologies can also be understood from the different levels that each allows. In AR, five levels can be distinguished based on different elements, which are used as information launchers: an artificial pattern in black and white or QR code, an image, a 3D object, a point on the planet determined by its GPS coordinates and thermal footprint (Cabero and Garcia, 2016). As regards VR, we find desktop or non-immersive, semi-immersive and full immersion; although some authors (Cañellas, 2017) only consider two types: Immersive, based on simulation of 2D or 3D scenarios in which the user perceives these scenarios with a feeling of first person "presence," as if being really immersed in it); Non- immersive, based on display of virtual scenarios through a screen, giving the feeling of being the person looking at the virtual stage from a "window".

At the summary level, we present the table prepared by the Innovation Observatory on Educational Technology of Monterrey (Table No. 1) where the fundamental differences between AR and VR are established.

Criterion	**AR**	**VR**
User interaction with the natural reality	**High** The real world is the environment with which one interacts from the digital information added to it.	**Low** The user is isolated from reality to submerge through a device into a fully digital sensory universe
Level of immersion in a digital experience	**Media** It depends on the digital density which adds to reality	**High** It involves complete immersion in a completely digitized parallel reality
Flagship device	Apps on Smartphones equipped with AR (e.g. Pokemon)	Sensory helmets (e.g. Oculus Ri)
Representative company in the development of technology	Google	Facebook
Development phase	In full expansive exploration	In reset, after the initial bubble

Table No. 1. Comparison between AR, VR and MR.

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4.2. Levels Of Development Of Ar And Vr And Technology For Its Observation And Production.

In AR we can distinguish different types and subtypes (Table No. 2).

According to physical component	**According to virtual component**	**According to its functionality**	
		Augmented perception	Creating an artificial environment
- AR Level 1: a pattern in black and white. - AR Level 2: an image. - AR Level 3: 3D entity. - AR Level 4: a point on the planet determined by coordinates GPS. - AR Level 5: thermal footprint.	- Image-based AR. - AR based on 3D. - video-based AR. - audio-based AR. - AR based on multimedia.	· Documented reality and documented virtual reality. · Reality with augmented perception or understanding. · Perceptual association of the real and the virtual. · Behavioral association of the real and virtual. · Replacing the real with the virtual or virtualized reality.	· Imagine the reality that could exist in the future, combining the real with the virtual. · Imagine the reality that was in the past, combining the real with the virtual. · Imagine an impossible reality.

Table No. 2. Types of AR (Cabero and Garcia, 2016).

A) VR Desktop or Immersive Systems: this is the most common and least expensive form of VR existing. Usually, it is simply made up of a desktop computer with common features, ability to play multimedia content or simulations that can be explored via the keyboard, mouse, joystick or a touch screen. These systems are completely devoid of feelings of immersion for the user. It allows easy use because there is no need to have specific devices. They can be very useful for quick observation of projects and actions.

B) Semi-immersive VR system: attempts to provide users a feeling of being slightly immersed in a virtual environment; it is performed by different types of software and through stereoscopic displays. They may include AR objects.

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C) Full immersion VR system: it consists of a pair of three-dimensional display screens mounted on a helmet on the user's head for complete isolation from the outside physical world; this category also includes virtual reality caves, a room where the walls surrounding the user produce three-dimensional images through various types of projection, offering the feeling of total immersion. In immersive environments, some special hardware is also required to interact with the environment, such as gloves, suits and sensor systems. Fully immersive virtual reality is considered the best option for transmitting multisensory information, including the ability to isolate almost completely any interference from the outside world and thus enable users to focus entirely on the information provided by the virtual environment.

Many resources are needed for observation and interaction with objects produced in AR and VR, and the first case, ranging from webcams connected to personal computers, game consoles, Smartphones, Tablets and special visors. In the case of AR, the most common devices are the Smartphone and Tablet. While in VR, viewers with additional equipment such as audio helmets, gloves, and special devices obtain the feeling of movement and control. Among viewers, we can point out personal computers and video game consoles: Oculus Rift, Razer OSVR hdk 2 HTC Vive Pro, or Playstation VR, Lenovo Explorer, or Windows 8 - Oculus Rift and Touch Controllers; and for Smartphone: Gear VR Google Cardboard, Google Daydream View, Acer AH101, or Samsung Gear VR.

Some programs for the production of objects in AR and VR are presented in Table No. 3.

AR PRODUCTION PROGRAMS	
HP Reveal	Software that does not require extensive knowledge to use. It works like a social network (https://www.hpreveal.com/)
Blippar	Simple application to use. It has a trial version, but the PRO version is for payment. (https://www.blippar.com/)
Zapwords	Simple application to use. It has a trial version, but the PRO version is for payment. (https://zap.works/)
Augment	Software that does not require extensive knowledge to be used (https://www.augment.com/)
Aumentaty	Software that does not require extensive knowledge to be used (http://www.aumentaty.com/index.php)
Unity 3D / Vuforia	Unity is an engine for creating video games that allows us to work with Vuforia for creating resources based on AR. Must have extensive knowledge in programming (https://unity3d.com/es)
ARkit	Apple Augmented Reality platform (https://developer.apple.com/arkit/)
ARCore	Google Augmented Reality platform (https://developers.google.com/ar/)
VR PRODUCTION PROGRAMS	
Unity 3D	Videogame design engine that serves both AR and VR. Depending on the type of device for which we are designing, we install the SDK pertinent to each brand (Magic Leap, Oculus, HTC VIVE ...) (https://unity3d.com/es)
Unreal Engine	Videogame design engine that serves both AR and VR. Depending on the type of device for which we are designing, we install the SDK pertinent to each brand (Magic Leap, Oculus, HTC LIVES ...) (https://www.unrealengine.com/)
KRpano	Application allowing creation of virtual reality environments in a simpler way than the previous two. (https://krpano.com/) .
CoSpaces	Easy to use environment for creating VR (https://cospaces.io/)

Table No. 3. Production programs in AR and VR objects.

4.3: What Educational Possibilities Do They Offer Us?

Both technologies offer diverse educational possibilities; and regarding AR, we can specify the following:

a) It eliminates information that is not significant for understanding a phenomenon. (Through these objects, we can include only the information that teachers considered significant to achieve the pre-established objectives and skills, having the student focus the observation on relevant aspects).

b) It enriches reality information to facilitate understanding.

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c) It allows observing an object from different viewpoints by choosing the person, time and viewing perspective.

d) It powers ubiquitous learning. (Needing reality for the construction of objects can provide learning experiences outside the classroom and thus promotes their contextualization, displaying links between reality and the learning situation in which students participate, promoting the development of learning in real and ubiquitous contexts. What we want to say is that, from this perspective, any physical space can become a stimulating academic setting).

e) It creates safe laboratories or simulators for students. (When the subject interacts on a new object constructed by the interaction of real and digital, possible negative consequences are avoided, particularly in security, involving laboratory practices and simulators).

J) It enriches printed documents with additional information in different formats. (Facilitates the development of interactive books, which can be enriched with different multimedia resources).

g) It allows students to visualize a phenomenon from multiple perspectives, thus enhancing spatial intelligence. (The observation of the objects from different perspectives and positions favors the development of spatial intelligence that facilitates information processing by the subject in three dimensions).

h) Students may be actors in producing these objects. (Students can become proconsumers of these objects.

i) It allows display of temporary and especially heterogeneous phenomena.

j) Possibility to contextualize information. (Cabero, 2018).

Regarding VR, although some are shared by the AR, the Technological Institute of Monterrey, incorporates the following possibilities:

- The sensory richness produced and its ability to generate an immediate response has an impact on improving students' attention.
- It enhances memory, both short and long term, due to the possibilities for the subject to recover experiences "lived" and not only learned instrumentally.
- It shortens the time of acquisition of certain skills, especially procedural.
- It promotes practical experimentation of theory.

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- It increases motivation toward instruction.
- It favors personalization of learning.

To these we could incorporate the following:

- Fidelity of the representation that is achieved with it, which refers not only to the representative fidelity but also the object's consistency of behavior.
- The interactivity that occurs in the subject determines the operation and development of the experience.

Regarding its significance for learning and performance, the meta-analysis of research conducted between 2005 and 2015 by Tekedere and Gökera (2016) determined the conclusion in the study that the average effect of AR applications in education was ES = 0.677. In other words, applications made using AR technology had a positive effect on students. At the same time, we must not forget that students highly value participation in these experiences (Martínez and Fernández, 2018).

Regarding students as producers of learning objects in AR, we conducted an investigation (Cabero, Barroso and Gallego, 2018) within the research project RAFODIUN (http://grupotecnologiaeducativa.es/proyectorafodiun/), in which, among various goals, we pursued: a) Knowing the educational possibilities offered by the student to become a producer of learning experiences supported by AR, b) Determining the degree of usefulness and value of AR production tools used by students. Study conducted in the subjects of Information Technology and Communication Applied to Early Childhood Education. Degree in Early Childhood Education and Educational Technology, taught at the Universities of Seville and Media education and educational dimension of ICT at the University of Córdoba. For this purpose, the following steps are followed: 1) conception of AR, educational opportunities and technical performance; 2) managing the Augment program and practical application of the tool; 3) Aurasma program management and practical application of the tool; 4) management of Quiver and Chromville programs for the production of objects in AR; 5) students' group work; and 6) students' presentations of productions to the class group.

For selection of the programs with which the students worked, a number of criteria were followed: cost of the tool (priority was given to free tools or trial licenses; programming skills (it was decided to opt for resources for which advanced computer knowledge is not needed for handling), technology (which allow midrange technology use), mobile applications (we opted for resources that have their own apps, without creating one exclusively for each resource, which would facilitate use); and educational use (which were designed for educational use applications, or at least are readily adaptable).

The duration of each session was 90 minutes, including theoretical and practical actions. However, in the 5th and 6th sessions, students had to invest more time beyond that regulated in the classroom.

Students were presented with three program themes on the subject, so that, on one of them, and organized by groups, they had to develop the learning object in AR. The contents that were offered were different depending on the subject; for example, in the case of the subject of Educational Technology, there were: Web 2.0, emerging technologies and the role of teachers and students in new technological environments. Thus, the contents were those of the subjects themselves.

Students worked in groups of between 3 and 5 people and 23 groups traditionally formed in the classes were established.

The objects made were designed taking 2D images as markers, and included digital video content and format Web links primarily; e.g., productions performed may be classified as "notes or books enriched with AR objects."

The experience was very meaningful. The students learned the contents by working in production, showing a high degree of acceptance of the technology, increased motivation for the development of the subject, and highly valuing the experience.

4.4. What Limitations Can We Find For Its Use In Training?

There are diverse limitations to inclusion in training, but before presenting them we would like to highlight two: the lack of research contributing principles on how to incorporate them into teaching, how to produce learning objects to facilitate students' interaction with them, or low in educational theories that we can use; and lack of or untimely educational experiences.

Regarding research, we highlight the project: "Augmented Reality to increase training. Design, Production and Evaluation of Augmented Reality Programs for University Education (ARFODIUN) (EDU2014-57446-P)", funded by the Ministry of Economy and Competitiveness of Spain. The results and publications derived from it can be seen at the following website: http://grupotecnologiaeducativa.es/proyectorafodiun/.

In addition to these, the most significant difficulties for inclusion in the training are: a) Not having an established theoretical framework that allows us to establish clear strategies for their use; b) The training the teachers may have; c) The very novelty of the technology; d) The constant and rapid evolution both technologies are acquiring along with software programming and production of objects; e) Cognitive dissociation produced by interacting in a context that mixes the real and virtual, or only virtual; f) Certain teachers' belief that these technologies are for fun and entertainment and not for instruction; g) Some authors' belief that they can only be used at higher levels of education; h) Students who are confused by their use; i) Immersion achieved to date with the VR space is limited to spatial immersion; that is, the perception of being physically present in a virtual world; j) The cost involved in quality production of objects in AR and VR; k) Lack of educational objects to be incorporated into teaching; l) The difficulty of using them with conventional technology devices since high speed data processing is needed; and m) Costs of hardware and software needed for production and use.

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4.5. Experiences In Ar And Vr.

Although we have previously pointed out that one of the problems with these technologies for incorporation into training is the lack of educational resources, we cannot forget that there are already different experiences that facilitate access to different types of resources, such as the site of "Quiver Education Series "(http://www.quivervision.com/education-coloring-packs/#education-starter-pack), the project" Google Expeditions "(https://edu.google.com/intl/es-419/expeditions/#about) that allows students to make different trips and expeditions both in AR and VR, or the aforementioned the "SAV of University of Seville" (http://ra.sav.us.es/) .

Different free tools are already appearing on the market so that teachers and students can comfortably and easily develop 3D animations and objects in AR and VR, without the need for programming expertise; among them we can mention: “CoSpaces Edu” (https://cospaces.io/edu/), “Appy Pie” (https://www.appypie.com/vr-ar-app-builder), “Google Tour Creator” (https://vr.google.com/tourcreator/), or “Paneek” (https://www.paneek.net/#/home).

Their educational uses are being carried out at different levels of education from primary to university and vocational training, as may be seen in the diversity of experiences presented in the work of Cabero, Leiva, Moreno Barroso and Lopez (2016) Villalustre and Del Moral (2016), and Cabero, De la Horra and Sanchez (2018).

We progressively encounter more experiences in AR and VR, which facilitate their incorporation into educational practice. Thus the "AR Alphabets" program (https://www.cordextoys.com/) is a tool for children to learn the alphabet in English using AR. Its operation is quite simple and intuitive, because once a code is downloaded and the program is given permission to access the Smartphone camera, by pointing to the code, the program will teach the alphabet with different objects and animals corresponding to each letter. Best of all, each item is displayed in 3D, having the ability to rotate and increase and decrease their size, as well as hearing their pronunciation. Also for learning English we have the "LinguaPracticaVR" program, a VR program offering free

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English classes in this technological context with images of places in Ireland and the United Kingdom. For example, in the screenshot below, you see an image of the Powerscourt cascade. Within this image, there are three short lessons about the words used to describe what is seen in the image.

The VR program "Titans of Space", which teaches students the solar system by making a tour of the planets and stars; this program can be customized depending on the interests and preferences of the viewer. Immersion in the human body through the "Anatomyou" program (https://anatomyou.com/), the student may approach different human systems (respiratory, digestive, circulatory, female reproductive, ...); although it is intended for university education, it can be used at other levels of education.

However, applications are not limited to uses for information transmitters or presenters of experiences and simulations, but are also developing different experiences for the treatment of various disorders such as dyslexia, with the project "Fostering Inclusive Learning for Children with Dyslexia in Europe by Providing Easy-to-Use Virtual and / or Augmented Reality Tools and Guidelines" (http://www.ticbeat.com/salud/tratar-la-dislexia-mediante-realidad-virtual-y-aumentada/) a project pursuing the educational inclusion of children with dyslexia by using AR and VR, thereby improving the access, participation and learning experience of the students who suffer from this problem. Different institutions participate in the project, such as the Research Group "Education, Inclusion and Technology" (EDINTEC) of the University of Burgos, the Asociata Bucaresti Pentru Copii Dislexici (Romania) and the Istituto Scientifico Eugenio Medea (Italy) and Spanish companies "Augmented Reality Software SL" and "Senior Europa SL" The strengths of the AR and VR is that they are technologies including immersion, presence, interaction, transduction and conceptual change. Thus, the activities carried out will approach real-life contexts and also take place in a dynamic, multisensory, controlled and secure environment.

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There is also the "Terapiam" project (http://www.fundacionmagtel.com/proyecto-terapiam/) of "Magtel", which aims to use AR for walking re-education in people with motor system impairments. The program presents a fun environment similar to a video game where, through an avatar, the patient is the protagonist of his or her own therapy. This allows users to continue semi-autonomously with their therapy, using a playful experience with AR through the use of numbers, colors and sounds, aiming to increase motivation, concentration and effort, so that the person completes the exercises and repetitions indicated in their rehabilitation treatment. The program consists of 18 activities and is aimed at people with physical and intellectual functional diversity from the age of six, as well as older people.

Moreover, an increasing number of museums are offering experiences in AR and VR for visitors, with the object of providing additional information to visitors. For example, the Energy Museum in Ponferrada incorporates an experience in AR and VR that provides a guided Google Expedition tour with which attendees can travel to the moon aboard Apollo 15, experience an authentic moon landing, and observe the earth from the moon. This is what is beginnings to be known as Virtual Heritage, and where there are already some notable experiences such as the "Smithsonian Museum of Natural History" Washington (https://naturalhistory2.si.edu/VT3/), the "British Museum" London (https://artsandculture.google.com/asset/british-museum/AwEp68JO4NECkQ), or the "Louvre" Paris (http://www.louvre.fr/en/visites-en-ligne).

At the university level, AR and VR are being incorporated heavily in various careers and studies. For example, the Technological Institute of Monterrey (Mexico) has extended its use in medical studies, and more specifically for learning anatomy, by using the 3D Organon VR Anatomy application (https://www.3dorganon.com/ and https://store.steampowered.com/app/548010/3D_Organon_VR_Anatomy/), which provides an overview of the human body. This application, similar to an anatomical atlas, includes over 4,000 models of highly realistic anatomical structures.

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The Catholic University of Valencia "San Vicente Martir," within the subject of Anatomy and Surgical Techniques, developed different objects in AR for the study of the anatomy of the leg and foot and the technique for Hallx abductus medial valgus in the form of a book enriched with AR objects. The experience has been described by Ferrer, Jiménez, and Torralba (2016), from whom we took some ideas for the description of the experience. For the production of the book, the first thing was to create 3D objects from images obtained by CT, processed with OsiriX software, then the final reconstruction of the anatomical structure was performed and coding was done. The objects produced are type 1, because a manual is needed to observe objects. As the authors of the document say: "It is a textbook with AR printed markers as the object of the main interface. Students can turn the pages of the book, looking at the pictures and reading the text without any additional technology. However, when looking at pages through a computer screen and webcam, 3D virtual models appear on the pages." (Ferrer, et al., 2016, 161).

The use of the training material is carried out from two perspectives: as a teaching resource and as material for autonomous learning. "The Professor begins the session by showing a normal view of the foot observing the incision and from there, taking advantage of the potentialities of AR, the three-dimensional image becomes semi-transparent in the portion corresponding to the skin until it disappears gradually and focuses the attention on the effect of the surgical material on the structures, always provided three-dimensionally. The progress in surgery, which is explained by the professor, is accompanied with successive phases shown every time the "Enter" key is pressed. They display virtually the function of the surgical material on the foot. (Ferrer et al., 2016, 162). The material was highly valued by students, and they obtained better grades than in previous courses.

Also at the university level, experiences are being developed in production of 360º objects that facilitate presenting different aspects of the University. In this sense, we can highlight the experience of the "SAV" at the University of Seville, with the production of different objects: "Guided tour of the University of Seville Rectorate" https://www.youtube.com/watch?v=zLXLUHZ2_SA CRAI presentation.

Information and Resource Center (https://www.youtube.com/watch?v=pEe9pKxHewo, or the School of Medicine promotional video (https://www.youtube.com/watch?v=NgnUmTQkD5E&t=24s).

To conclude this section, we present different projects and their level of specificity, so that the interested reader can deepen the understanding of the application of AR and VR in the educational field.

- Elements 4D: Cubes showing an element of the periodic table. Information on each of the elements is provided (https://apkpure.com/es/elements-4d-by-daqri/com.daqri.elements4dbydaqri).
- ARcircuits: This facilitates the performance of a comprehensive electricity study. It provides digitized different markers to build different electrical circuits. (http://arcircuits.com/).
- Anatomy 4D: With this AR application, you can take a tour through all the systems that make up the human body and heart. To use it, you must first download the application on a cell phone or tablet, and then download the page http://daqri.com/project/anatomy-4d/#.VMKfk8a9Kok model that will act as a trigger marker for the AR image. (http://daqri.com/project/anatomy-4d/#.VMKfk8a9Kok).
- SpaceCraft 3D: Application developed by NASA in which a collection of satellites and robots used in special missions are shown. (https://www.jpl.nasa.gov/apps/).
- Arloon: Set of AR applications for different educational levels which relate to different areas of knowledge: geometry, anatomy, chemistry, ... (http://www.arloon.com/).
- Zookazam: AR program that offers different animals divided into different categories (http://www.zookazam.com/).

In conclusion, we indicate four aspects that are important to consider for the incorporation of these technologies in training: a) The need to expand research and educational practices carried out on these technologies to establish efficient mechanisms for incorporating these technologies; b) Searching for conceptual models that establish frameworks for incorporation into training; c) Incorporating broader learning objects to facilitate their incorporation by teachers; and d) The use of these learning objects must overcome the experiments that highlight leisure and overestimation of technology to find practices in which students have an active and participatory attitude.

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